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FEEDING TRIALS WITH CONCENTRATED FISH SILAGE FOR FOX AND MINK

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Fish silage manufactured of whole fish or fish offal has been tested in a number of trials carried out with mink by The Institute for Poultry and Fur Animals. E.g. in 1984, mink, Arctic fox, and silver fox feeding trials were conducted with formic acid-preserved silage made of herring offal. Use of 23-% herring silage yielded positive results, particularly in trials with fox.

The company Bjugn Industrier A/S has developed a new method for manufacturing fish silage. Briefly described, the method consists of preserving the raw material, such as capelin, Norway pout, herring and fish scrap, with 1.3 - 1.8 % formic acid and ethoxyquin as antioxidant, followed by further processing which includes, most importantly, concentration to about 55 % dry matter and adjustment of the fat content to the desired level. Thus, it is possible to produce concentrated silages with different protein/fat ratios, which results in flexibility and adaptability with regard to the various needs that depend on other supplies of raw material for fur animal feed. The silage is also subjected to a heat treatment which destroys enzymes, such as thiaminase. The finished product has a pH of about 4.2 - 4.3, and it will thus increase the acidity of the feed.

Trials were conducted in 1985 and 1986 with four batches of concentrated fish silage from Bjugn Industrier A/S. The present report discusses the results from the first three batches; the fourth trial was carried out this fall. All batches were delivered in Nofo cans and stored at room temperature in our premises.

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Nutritional value

The table below shows the percentages of dry matter, protein, fat and ash in the three batches of concentrated fish silage.

	Batch 1	Batch 2	Batch 3
Delivery date	16.7.85	16.7.85	9.1.86
Dry matter, %	51	54	53
Protein, %	32	20	33
Fat, %	14	30	15
Ash, %	5	4	5

All batches were requested to be delivered with a certain protein/fat ratio. Analyses showed an acceptable agreement with the levels ordered.

Batches 1 and 3 were tested for digestibility in February 1986.

Thus, Batch 1 was stored for about 7 months before the digestibility trials, while Batch 3 was only 1 month old at this time point. The trials were carried out with standard male mink born in 1985. Concentrated fish silage was the only protein source in the simple feed mixtures used. No problems were encountered with feed uptake.

The trials showed that both silage types had generally high digestive values. The true digestibility of the protein was determined to be 92.9 % for Batch 1 and 93.6 % for Batch 3. If compared with regular table values for fur animal feed, which give apparent digestibility, these values have to be reduced to about 89 %. Fat digestibility was quite high as well, 95.2 % for Batch 1 and 95.9 % for Batch 3, being at the same level with the regular values for pure fish oil.

Table 1 shows amino acid contents and amino acid digestibilities for Batches 1 and 3. The amino acid analyses indicate good protein quality. The most important amino acids had contents comparable with the regular values for fish scrap of good quality. The amino acid digestibility could be considered good, and differences were small between the two batches. Thus, it seems that the digestibility of amino acids was not affected to an appreciable degree by the 7-month storage. The only exception was the digestibility of cystine, which was significantly lower in the batch that was stored

longer. However, this may have been caused by other reasons.

Table 1 Amino acid contents (g/16 g N) and true amino acid digestibilities (%) for concentrated fish silage

Amino acid	Batch 1		Batch 3	
	Content	Digestibility	Content	Digestibility
Lycine	6,9	96,6	6,7	97,2
Methionine	2,6	97,4	2,5	97,5
Cystine	0,8	85,2	0,8	91,7
Asparagic acid	7,8	89,4	7,2	91,1
Treonin	3,8	96,6	3,6	97,0
Serine	3,9	95,0	3,7	96,3
Glutamic acid	11,2	91,4	10,7	93,8
Proline	3,5	94,4	3,5	95,8
Glycine	4,9	94,9	4,5	94,7
Alanine	4,7	99,2	4,5	99,1
Valine	4,4	97,7	4,2	97,8
Isoleucin	3,7	97,9	3,4	97,9
Leucin	6,0	98,9	6,1	98,4
Tyrosine	2,8	98,2	2,9	98,3
Histidine	3,4	98,6	3,3	98,4
Arginine	1,8	96,2	1,7	97,1
	5,7	98,0	6,0	98,5

Fatty acid analyses and measurements of fatty acid digestibility were also carried out (Table 2). The analyses indicated that there was a large content of the typical long-chain unsaturated fatty acids of fish oil. These fatty acids are digested very well, which was also demonstrated in earlier trials with pure fish oils. Stearic acid was found to have the lowest digestibility (C 18:0).

Table 2 Amino acid content (%) and fat digestibility (%) in concentrated fish silage

Fatty acid	Batch 1		Batch 3	
	Content	Digestibility	Content	Digestibility
C 14:0*	5,6	99,4	6,2	99,4
C 16:0	12,9	95,7	12,2	96,2
C 16:1	6,7	98,8	8,0	98,6
C 18:0	2,0	75,8	1,7	68,3
C 18:1	14,9	96,2	12,4	96,9
C 18:2	2,7	87,3	1,9	90,4
C 20:1	17,6	97,4	17,6	97,9
C 22:0	0,8	87,0	0,8	93,2
C 22:1	16,3	95,5	19,6	95,8
C 20:4	6,2	95,0	6,6	96,5
C 20:5	2,4	88,4	3,0	90,3
C 22:5	1,0	88,3	1,1	88,7
C 22:6	8,4	96,5	6,8	95,0

*) Carbon atoms : double bonds.

Production trials with fox, July to pelting, 1985

Arctic fox and silver fox cubs were subjected to parallel trials with the same feed composition. In principle, the trials groups were as follows :

1. Control, without silage
2. Concentrated silage, Batch 1 (14 %)
3. Concentrated silage, Batch 2 (15.4 %)

Each group contained 32 Arctic fox cubs born on time (16 males and 16 females). The silver fox cubs numbered 24 (12 males and 12 females) in Group 1 and 22 (11 males and 11 females) in Groups 2 and 3. The groups were formed so that their genetic background and body size were as similar as possible. The trials started on 17-19 July and ended at the time of pelting.

Feed composition is shown in Table 3.

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Table 3 Feed composition in trials with concentrated fish silage for foxes, 1985 (%)

	1	Group 2	3
Conc. fish silage, Batch 1	0,0	14,9	0,0
Conc. fish silage, Batch 2	0,0	0,0	15,4
Cod scrap	9,7	0,0	11,1
Pollack scrap	13,6	0,0	0,0
Slaughter waste	9,7	12,1	11,1
Blood	4,9	6,1	5,6
Fish meal	5,8	7,3	6,8
Protamyl	1,9	2,4	2,2
Gelatinized carbohydrate feed	15,6	19,5	17,4
Preventive feed	1,0	1,3	1,2
Lard	2,9	3,6	1,9
Capelin oil	2,4	1,5	0,0
Hemax	0,2	0,2	0,2
Water	32,3	32,0	27,1
Conv. energy (kcal/100 g)	149	186	181

The control feed had a composition closely related to the feed list of the Norwegian Fur Breeders Association.

The capelin oil used was a new type with TBHQ (tertiary butyl hydroquinone) as antioxidant.

In the feed for Group 2, concentrated fish silage with a moderate fat content constituted about 1/3 of the digestible protein and about 20 % of the digestible fat. The essential change, in comparison with Group 1, was that all fish scrap was substituted with fish silage. This resulted in a strong increase in concentration. Besides, the capelin oil content was somewhat reduced, because the fish silage contained more fat than the fish scrap. The percentages of the other feed components were changed to correspond to the changed concentration.

In the feed of Group 3, fatty concentrated fish silage constituted about 19 % of the digestible protein and about 50 % of the digestible fat. The changes, in comparison with Group 1, were that pollack scrap and capelin oil were not included at all and that the lard content was reduced. Otherwise, the changes were insignificant, with the exception of that concerning the water content.

The trials were conducted without any problems. A female Arctic fox died of overloading of the stomach on September 12. There was no other mortality.

Table 4 shows the most important results of the Arctic fox trials.

Growth was good in all groups, and there were no signs of negative effects of concentrated fish silage at any stage of the growth period. When silage with moderate fat content was used, there was a tendency towards increased final weight and skin length. With a few exceptions, all the animals were pelted, and most skins were sold at the March event of the Oslo Fur Auctions. The quality grading at the auction and the skin prices indicated that the quantities of concentrated silage that were used in this trial did not at any rate have a negative effect. On the other hand, the groups did not differ from each other sufficiently to allow a sure determination of a positive effect.

The results of the trials with silver foxes are shown in Table 5. The groups receiving concentrated fish silage showed somewhat better growth than the control group, and the skins were a little larger. It is difficult to evaluate the results on the basis of the skin data, because a relatively large number of the animals were being kept for breeding purposes. However, the main impressions gained were that quality was evenly good all through and that it was not possible to find any differences in skin properties between the groups. The average price of all silver fox skins from this trial, sold at the Oslo Fur Auction's March event, exceeded the mean price of the auction by NOK 101.00 .

Table 4 Results of trials with concentrated fish silage for Arctic fox from July to pelting

	Control	Concentrated fish silage	
		Batch 1	Batch 2
Initial weight on 11.07. (g)	1980	1971	1983
Weight at pelting (g)	7439	7882	7565
Carcass length at pelting (cm)	63,8	63,8	63,8
Skin length (cm)	101,8	102,7	101,8
Skin appraisal (points) *)			
Hair quality	6,3	6,4	5,9
Thickness	6,6	6,5	6,5
Total impression	6,5	6,7	6,4
Skin quality, O.S. **)	3,1	3,4	3,2
Skin price, in NOK	330	338	339

*) Point scale : 0 (poorest) to 10 (best); appraised at the College of Agricultural Engineering

**) Results of regular quality grading at the Oslo Fur Auctions (Saga Selected = 4, Saga = 3, 1st grade = 2)

Table 5 Results of trials with concentrated fish silage for silver fox from July 10 to pelting

	Control	Concentrated fish silage	
		Batch 1	Batch 2
Initial weight (g)	3073	2836	2838
Weight at pelting (g)	6877	7086	7103
Growth increment (g)	3804	4250	4265
Carcass length at pelting (cm)	69,6	69,6	70,5
Skin length (cm)	102,2	104,7	104,1

Trials with fox and mink in the 1986 reproduction period

During the reproduction season, the concentrated fish silage trials included Arctic fox and standard mink (wild mink type). The same feed was used for both fox and mink. The following trial groups were included.

1. Control, without silage
2. Concentrated fish silage, Batch 3 (5.8 %)
3. Concentrated fish silage, Batch 3 (13.2 %)

Each group consisted of 14 - 16 female Arctic foxes and 32 female minks grouped on the basis of genetic background, weight, age and possible earlier reproductive performance.

The trials started on January 9 and ended when the pups reached weaning age (7 weeks for fox and 6 weeks for mink).

Table 6 shows the feed composition of the trials.

Table 6 Feed composition in trials with concentrated fish silage for fox and mink in reproductive season 1986

	1	Group 2	3
Concentrated fish silage	0,0	5,8	13,2
Industrial fish	20,0	11,5	0,0
Cod scrap	10,0	11,5	13,2
Slaughter waste	12,0	13,8	15,9
Blood	6,0	6,9	7,9
Fish meal	7,5	8,6	9,9
Gelatinized carbohydrate feed	9,0	10,4	11,9
Preventive feed	2,0	2,3	2,6
Lard	2,5	2,4	2,2
Soya oil	0,5	0,6	0,7
Hemax	0,2	0,2	0,2
Water	30,3	26,0	22,3
Conv. energy (kcal/100 g)	126	145	167

Concentrated fish silage, at 5.8 % and 13.2 %, was substituted for industrial fish. Because of the different protein/fat proportion, the lard quantity had to be decreased somewhat when silage was used. As shown in Table 6, water content was decreased when silage was used, depending on feed consistency. This resulted in changed percentages for all feed constituents (except Hemax) and in a strong increase in energy production with increased level of concentrated fish silage.

However, energy production based on dry matter was practically unchanged. For all feed mixtures, the energy distribution was calculated to be 43 % from protein, 41 % from fat and 16 % from carbohydrates.

Table 7 summarizes the reproduction results, cub mortality, and cub weights at the time of weaning, in trials with Arctic fox. The results can be considered satisfactory, and no significant differences were found between the groups.

Table 7 Results of trials with concentrated fish silage for Arctic fox in reproductive season

	Concentrated fish silage (%)		
	0	5.8	13.2
Number of females	15	16	14
Number of females mated	15	16	14
Number of females whelping	13	14	14
Cubs per litter at birth	.9,8	10,3	8,9
Cubs per breeder female			
at weaning	7,0	6,9	7,5
Cub mortality before			
weaning (%)	17	22	15
Average cub weight (g)			
at 48 days	1725	1701	1800

Table 8 shows the results of similar trials with mink. Among the mink, reproduction reached a satisfactory level as well. The two groups receiving silage showed a tendency to have more numerous unfertilized females and fewer pups born per litter, but the differences between them and the control group are not significant. Also, pup weights at birth were somewhat lower in the groups receiving fish silage. Furthermore, it is interesting to see that as much as 13.2 % concentrated fish silage did not affect the growth increment of the mink pups in the critical period before weaning. This means that the tastiness of the feed was not essentially reduced, even when the pH of the ready feed was as low as 5.3 - 5.4 .

Table 8 Results of trials with concentrated fish silage for mink during reproductive season

	Concentrated fish silage (%)		
	0	5.8	13.2
Number of females	32	32	32
Unfertilized females (%)	3	13	9
Pups per litter at birth	7,3	6,4	6,5
Pups per breeder female			
at weaning	5,9	4,6	4,6
Pup mortality before			
weaning (%)	16	17	22
Average pup weight (g)			
At birth	9,7	8,9	8,7
21 days after birth	116	117	119
At weaning	330	317	328

Discussion and conclusions

Fish silage has a concentrating effect on ready feeds, as it will make the dry matter content increase considerably. Therefore, trials have been carried out with different energy concentrations in feed mixtures. However, energy contents were little affected on the basis of dry matter, and energy distributions were adjusted to similar levels in the mixtures to be compared.

Concentrated fish silage increases the acidity of the feed. The silage used in the trials contained, according to our analyses, about 4 % formic acid. The pH values were measured to range from 4.2 to 4.3, and they kept stable during our storage conditions.

Since the trials revealed no negative effects from the use of concentrated fish silage, it is possible that bigger amounts can be used than those used in the trials, especially for fox and in the period from weaning to pelting. It would be interesting also to try concentrated fish silage together with other acid-preserved feed components.

The trials produced almost identical results for concentrated fish silages with different protein/fat ratios. Therefore, it will be largely the price of the fat and the protein in the silage, compared with the price of alternative feed components, that will determine which type of silage is economically optimal. Also, fat-poor silage will increase the energy level of a feed, because it will increase the dry matter content of the feed mixture.

Concentration of silage has obvious advantages with regard to transport and storage. The high digestibility values found in our trials indicate that the heat treatment carried out was very gentle and probably without effect on digestibility.

Concentrated fish silage of the type and quality used in the trials proved to be a reasonable and useful feed for fur animals. Therefore, the increasing interest in this type of feed components is well founded. The acid content and acidity degree of the ready feed mixture seem to be the factors deciding how big quantities can be used in feed mixtures for fur animals.